

AUTONOMIC NON-INTRUSIVE BACKUP AND STORAGE APPLIANCE

RELATED APPLICATIONS

[0001] This Application is related to United States Application No. _____, entitled, "Autonomic Image Migration/Deployment Appliance," filed contemporaneously herewith.

5 TECHNICAL FIELD

[0002] The instant invention relates in general to a file storage system and method for a computer system. The invention is well-suited to system backup and restore procedures as well virtual network storage needs.

BACKGROUND

10 **[0003]** Within the prior art, backup and restoration of a computer system requires relatively large backup software programs (15-25 MB) to make an image of the computer system storage media. Some examples of these programs include softwares offered by XPOINT TECHNOLOGIES and POWERQUEST, each very popular in the art. Installation of these types of programs generally have extensive installation side effects, such as the resizing or creation of
15 partitions on the main system storage media and/or extensive modifications to the computer operating system. These installation side effects can cause incompatibilities with other installed software, can diminish available resources for other computer functions, and makes the installation process more complicated for a user to accomplish. Additionally, the state of the art backup programs do not present a very flexible model of backup storage. Images are typically
20 made of the source, making a partial restoration impossible due to the sector allocation inherent in most file systems.

[0004] Similarly, network storage is accomplished in the prior art one of two ways. Under the first model, an extensive agent resides on the node computer system, managing the data interactions with a relatively simple server software on the network server. Under the second model, a smaller agent resides on the node, requiring more extensive server software on the network server to fully manage the data storage functions. Under either model, modifications to the node computer system are required, creating side effects similar to those seen with the backup systems. For proper operation, the network storage systems often require the allocation of storage space to the node network agent program and the modification of the operating system on the node. These side effects result in the same compatibility, storage and complexity issues seen with backup systems.

[0005] Both the backup and the network storage functionalities present significant expense to the user desiring to effectively use them. In addition to the expense of acquiring the software for backup and for the network storage, each requires additional hardware resources, installation expense and user training.

15 SUMMARY OF THE INVENTION

[0006] The instant invention provides an appliance which is suitable for the backup and restoration of a computer system, which may be used locally or in the context of a computer network system. The instant invention features the simplicity of a plug-and-play type technology yet the power to be able to be used within large organizations effectively. As a result, the instant invention provides the unexpected benefits of an easier, more cost-effective backup and restoration model.

[0007] The foregoing outlines broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter

which form the subject of the claims of the invention. The instant invention offers many advantages over these prior art systems, and presents several additional benefits that will be apparent to the reader skilled in the art.

DESCRIPTION OF THE DRAWINGS

5 **[0008]** A more complete description of the instant invention is made with reference to several figures:

Fig. 1 is a system diagram depicting a computer hardware system and its configuration when used in the instant invention;

10 **Fig. 2** is a system diagram depicting an embodiment of the hardware configuration of the instant invention;

Fig. 3 is a system diagram depicting an embodiment of a network hardware configuration of the instant invention;

Fig. 4 is a flow chart drawn in conformance to the ANSI/ISO 5807-1985 specification and depicting backup operations under the instant invention;

15 **Fig. 5** is a flow chart drawn in conformance to the ANSI/ISO 5807-1985 specification and depicting restoration operations under the instant invention;

Fig. 6 is a block diagram depicting the composition and use of the storage address generator in accordance with the instant invention;

20 **Fig. 7** is a system diagram depicting an embodiment of a diversified network hardware configuration of the instant invention; and

Fig. 8 is a data diagram depicting the storage of backup data under the instant invention in a distributed system.

Fig. 9 is a flow chart drawn in conformance to the ANSI/ISO 5807-1985 specification and depicting the procedure for booting from the operating system stored in the appliance.

DETAILED DESCRIPTION

[0009] In the following description, numerous specific details are set forth such as computer programming languages, database structures, computer operating systems, microprocessors, bus systems, integrated circuits, protocols, input/output (I/O) systems, etc., to provide a thorough understanding of the invention. However, it will be obvious to those skilled in the art that the present invention may be practiced without such specific details. In other instances, well-known protocols, data formats, computer equipment, and I/O systems have been shown in block diagram form in order to not obscure the present invention in unnecessary detail. For the most part, details concerning timing considerations, specific languages used, specific database structures used, specific data formats used, and the like have been omitted inasmuch as these details are not necessary to obtain a complete understanding of the present invention and are well within the skills of persons of ordinary skill in the art.

[0010] A representative computer hardware environment for practicing the present invention is depicted with reference to **Fig. 1**, which illustrates a hardware configuration of a data processing system **113** in accordance with the subject invention. The data processing system **113** includes a central processing unit (CPU) **110**, such as a conventional microprocessor, and a number of other units interconnected via a system bus **112**. The data processing system **113** includes a random access memory (RAM) **114** and a read only memory (ROM) **116**. Those skilled in the art will appreciate that the ROM **116** could be replaced or supplemented by a number of semi-permanent chip-based storage devices, such as programmable read-only memory (PROMs), erasable programmable read-only memory (EPROMs), and the like (not shown). Also included are an I/O adapter **118** for connecting peripheral devices such as disk units **120**, tape drives **140** and CD or DVD drives **144** to the bus **112**, a user interface adapter **122** for connecting a keyboard **124**, a mouse **126** and/or other user interface devices such as a touch screen device (not shown) to the bus **112**, a communication adapter **134** for connecting the data

processing system **113** to a data processing network **142**, and a display adapter **136** for connecting the bus **112** to a display device **138**. Also, a universal serial bus (USB) adapter **146** may be fitted to the bus **112**. The CPU **110** may include other circuitry not shown herein, which will include circuitry found within a microprocessor, e.g. execution unit, bus interface unit, 5 arithmetic logic unit (ALU), etc. The CPU **110** may also reside on a single integrated circuit (IC).

[0011] The representative hardware environment depicted in **Fig. 1** may be suitable to execute the system to be described. It will be understood that references to a “computer” in this disclosure are to a hardware system similar to that depicted and described with reference to **Fig.**

10 **1.** Those skilled in the art will appreciate that the description with reference to **Fig. 1** contains many of the elements common to a computer hardware system, but that a computer hardware system may be operable without every element described in **Fig. 1**. Accordingly, references to a “computer” may exclude elements disclosed, so long as functionality is maintained. Similarly, modifications and additions may be made to the hardware system, all falling within the definition 15 of “computer” within this specification.

[0012] It will be appreciated that the computer disclosed herein is suitable to execute client-side and server-side applications in client-server environments. In such environments, certain adaptations may be made to each computer in order to maximize efficiencies in these respective roles. Further, it will be apparent to those skilled in the art that certain of the computers 20 referenced may be embodied in one or several of the computers as depicted in **Fig. 1**. Several computers may operate in parallel or in series, filling the function of a single computer and in some cases achieving greater efficiencies.

[0013] The basic operation and hardware configuration of the instant invention is described with reference to **Fig. 2**. **Fig. 2** depicts a single computer backup system **201** in conformance 25 with the present invention. The single computer backup system **201** comprises a computer **203**

that is the subject of the backup or restore procedure. The computer **203** is electrically connected to a program appliance **207**. The program appliance **207** may be one of several types of appliances, so long as the appliance **207** provides for at least read-only storage. Shown is a USB appliance **207**, connectable to the computer system **203** via a USB interface. The USB appliance

5 **207** is configured so as to appear as a disk drive to the computer **203**. A backup program and/or a restore program, of the type and configuration described herein, is stored within the program appliance **207**.

[0014] The single computer backup system **201** further comprises a data storage appliance **205**, electrically connected to the computer **203**. The data storage appliance **205** may be one of 10 several types of appliances, so long as the appliance **205** is capable of read/write storage. Shown is a Read/Write CD drive **205**, connectable to the computer **203** by means of a typical I/O interface, such as an Integrated Drive Electronics (IDE) interface or a Small Computer System Interface (SCSI).

[0015] Generally, pursuant to the invention, the backup program resident on the program 15 appliance **207** directs the computer **203** to copy the files from its hard drive storage system onto the data storage appliance **205**. This method of operation is in stark contrast to the prior art, under which a backup program would be installed on the computer **203** which would then instruct the computer **203** to copy data from the computer **203** hard drive to a data storage appliance **205**. Similarly, restoration is accomplished via a restoration program (or a restoration 20 function of the backup program), resident on the program appliance **207**.

[0016] Though two appliances, one for the program **205** and one for data storage **207**, are shown on **Fig. 2**, it will become clear upon further explanation that only one appliance **207** is necessary, though two appliances **205**, **207** can be used. If a single appliance **207** is equipped 25 with a read/write capability, such as is the case with a read/write CD drive, a USB hard drive, or similar storage devices, then the single appliance **207** may perform the functions of the program

appliance **207** as well as providing a medium for the storage of the data. The single appliance version has several distinct advantages, not the least of which is the simplicity inherent in a backup and restoration solution requiring a single step of attaching the appliance **207** in order to begin and complete the backup or restoration of the computer **203**.

- 5 [0017] Restoration of data backed up on the data storage appliance **205** may be accomplished through the same hardware configuration shown on **Fig. 2**. The programming on the backup appliance **207** is replaced by or may be supplemented with restoration programming, as will be described hereinafter. The restoration program on the appliance **207** directs the computer **203** to copy data from the data storage appliance **205** to the computer **203**.
- 10 [0018] A hardware configuration of the instant invention in a network environment is shown with reference to **Fig. 3**. **Fig. 3** shows a network system **301** having a computer **303** to be backed up. The computer **303** is in electrical connection with a network port **307**, which is in turn in electric communication with a network **309**. Although the network **309** shown is nominated as an Ethernet network and in block form, those skilled in the art will appreciate that 15 the type and configuration of the network is irrelevant to the operation of the instant invention. Accordingly, the invention could be practiced on any number of network systems, including a token ring system or a system having wireless, hubbed or routed components, without changing the effect of the invention, and all falling within the scope of the disclosure.
- 20 [0019] The network **309** provides data communication from the computer's port **307** to a second port **305**. In electric communication with the second port **305** is a host computer **315**. The host computer **315** may be another computer on the network **309** similar to the backup computer **303** or in the alternative may be a computer that is optimized to operate as a server on the network **309**.

[0020] Under the present invention, a program appliance **311** is placed in data communication with the backup computer **303** (in the same manner as illustrated as to elements **203** and **207** with regard to **Fig. 2**). The program appliance again contains a backup/restore program which operates in accordance with the instant invention. Prior to or contemporaneously 5 with the attachment of the program appliance **311** to the backup computer **303**, a data storage appliance **313** is attached to the host computer **315**. Operation of the program appliance **311** is the same as disclosed with reference to **Fig. 2**, except that data files from the computer **303** to be backed up are transmitted over the network **309** for deposit upon the data storage appliance **313**. Similarly, restoration is accomplished similarly over the network **309**. As was disclosed with 10 reference to **Fig. 2**, the appliances **311**, **313** are shown as USB appliances, but may be any number of different types of appliances, ranging from USB drives, CD drives (for appliance **311** only), read/write CD drives, and the like. Additionally, it will be appreciated by those skilled in the art that the data storage appliance **313** may be omitted entirely, the data from the backup instead stored directly on the hard drive of the host machine **315**. In this embodiment of the 15 invention, it is more likely that the host machine **315** is configured particularly as a server, so as to provide the large storage space and communications buffers which would maximize performance.

[0021] It will be appreciated that the use of the invention in the network hardware environment **301** permits the program appliance **311** to be moved from the backup computer **303** 20 to other computers (not shown) connected to the network with relative ease. Accordingly, backups of all of the computers on a network **309** may be accomplished without invasion of the backup computers **303** nor the host/server computers **315** with installed programs which might corrupt, modify or interfere with the proper normal operation of those computers **303**, **315**.

[0022] The operation of the backup functions of the program appliance **311** are shown in 25 more detail with reference to **Fig. 4**. **Fig. 4** depicts the method **401** of backup operations.

Operations begin **403** with the precondition of a computer system having a hard drive or other media that is in need of backup. First, the program appliance is connected **405** to the subject computer. Upon such connection, the operating system of the computer detects the connection **407**. The means for detecting the connection of a new media device are well known in the art, 5 and are typified by the plug-and-play capabilities of operating systems such as Windows XP.

[0023] Many operating systems provide not only for detection **407** of the new media made available to a computer, but also provide for the automatic execution of programs placed in specific locations within that media. For example, under Windows XP, inserting a new CD or attaching a new USB drive will cause Windows XP to seek and execute the commands located in 10 the AUTORUN.INF file. By equipping the program appliance with an AUTORUN.INF file in its root directory, the insertion of the new media causes the automatic execution of the backup/restore program resident on the appliance.

[0024] Upon the execution of the program resident on the appliance, first the evaluation is made as to whether the program appliance is configured for fully-automatic operation **409**. 15 Those skilled in the art will appreciate that this evaluation may be made any number of ways. The appliance program may query the operating system and/or the microprocessor in order to determine the serial number of the machine, comparing that number against a table of configuration parameters, in order to determine whether automatic operation is enabled. In an alternative embodiment, the user may be queried as to whether automatic operation is desired. In 20 yet an alternative embodiment, files may be stored on the backup computer which indicate certain preferences as to the automatic operation of the appliance. Note, however, that the embodiment which places configuration files on the backup computer would no longer provide a system which operated without interfering with the hard drive on the backup computer.

[0025] If the program is not set for automatic execution, then the program has the operating 25 system provide **411** notice to the user of the manner in which execution may be activated.

Notice may come in several forms. In one embodiment, an icon is provided in a toolbar or desktop. In another embodiment, the user may be provided dialog boxes with instructions on how to activate the program for the backup procedure. In any event, the program operation halts or discontinues until such time as the user manually activates **413** the program. Activation may

5 be by clicking or double-clicking an icon, typing a keyboard command or any other means of signaling the computer to begin or continue a program.

[0026] Once the user initiates **413** or, if automatic operation was enabled **409** immediately, the program first checks with the operating system to ensure that the user has sufficient authorization rights to make a full backup of the computer. Typically, operating systems will

10 lock sensitive or system-critical files from the direct access of the normal user. Generally, supervisor or administrator rights, at least as to the local system, will be required in order to make proper access to those system files for copying to any backup media. After inquiry as to the level of access is made, that level of access is checked **417** to ensure that it is sufficient to permit a full backup.

15 [0027] If sufficient authorization is not inherent in the user's login credentials, the user is prompted **419** to enter sufficient credentials to permit access of all of the system files, at least on a read-only basis. Once those credentials are entered **419**, they are again queried with the operating system **415** and evaluated to see if they are sufficient **417**. The user may exercise the option, if he or she does not have sufficient credentials, to quit the program **423** without having

20 made a backup.

[0028] If sufficient credentials are demonstrated, the program copies **421** the files from the hard drive of the subject computer onto the data storage medium. Files are copied on a file-by-file, rather than a bit-by-bit, basis. Accordingly, the files may be stored contiguously on the data storage medium and are retrievable individually or in groups without retrieving the entire

25 backup. Those skilled in the art will appreciate that various compression technologies, well

known in the art, including hardware and software-based technologies, may be used to condense the amount of space that the backup files occupy on the data storage medium.

[0029] During the copying **421** of the files from the hard drive to the data storage medium, the files may be flagged with the archive bit, if the operating and/or file system is so equipped, to 5 indicate that a copy of the file has been made. Similarly, the system of the instant invention permits the well-appreciated art of incremental backup to be practiced. Under this backup schema, a full backup of the computer is made periodically on a longer time frame (for example, monthly). Between full backups, incremental backups are performed, which only make copies of the files that have changed since the last backup. In this way, much faster backups are possible 10 on a normal, daily basis.

[0030] It will further be appreciated that the process of copying the computer data to the data storage appliance may, in an embodiment, also make note of the identity of the backup, the machine and/or time of the backup. This information allows the distinguishing of several sets of backup files within a single data storage appliance. In this way, a single data storage appliance 15 may be used for several backups over time or for the backup of several machines.

[0031] The backup operation **401** ends **423** with the post condition of either a completed backup or the generation of an error. Possible errors may be failure of authentication (and the user instruction to quit **417**), hardware failure or full data storage errors.

[0032] In the normal case, however, the completion of the backup operation **401**, if 20 configured for automatic operation and initiated by someone with supervisor credentials, provides a single-step backup (absent any errors) when used in conjunction with the hardware configurations previously described. Moreover, the instant invention provides for such a backup to be made without any modifications to the computer backed up and without the installation of

any programs. Such a system provides several non-obvious benefits over the prior art, in which a backup program is installed directly on the computer to be backed up.

[0033] The restoration procedure is shown with reference to **Fig. 5**. **Fig. 5** depicts the restore operation **501** in accordance with the instant invention. The operation **501** begins **503** with the 5 precondition of a backup having been made in accordance with the instant invention. In an optional step that may not be present in some embodiments of the invention, the Basic Input/Output System (BIOS) may prompt the user to authenticate his or her access to the hard drive onto which restoration is required. Execution passes to the next step only upon entry of the proper authentication.

10 [0034] Next, the user connects **505** the program appliance and the data storage appliance containing the backup to the computer. Execution next depends upon the presence of an operational operating system **507**. It will be appreciated that in a situation where restoration is desired of a system, there may be times when the existing operating system and/or data files are existing and operational, but corrupt. There may be other times when, for example due to 15 hardware failure, blank media is to accept the restored files. In still other instances, operating system files may exist, but the entire operating system will not be present in an operational form.

[0035] In the case of blank media or a non-operational operating system, execution continues depending upon **517** whether the appliance system is set for automatic operation. This inquiry is based upon the availability of the ability of the BIOS in the computer to boot from the appliance. 20 If automatic operation configuration is set, the BIOS is set to boot from the appliance, if present. If not, user intervention **519** is required to properly configure the BIOS to enable a boot from the appliance. It is to be recalled that the appliance may be any number of devices, such as a USB device or CD drive. Accordingly, both the determination **517** of the proper auto configuration settings and the manual setting **519** of the BIOS parameters will vary from instantiation to 25 instantiation of the instant invention, depending upon the nature of the appliance used.

[0036] Execution proceeds with the computer booting **521** an operating system from the appliance. Full details of this procedure are described hereinafter, with reference to **Fig. 9**, but omitted here for the sake of clarity. However, it should be appreciated the basic function, which is to boot the computer with an operating system and install that operating system to the hard

5 drive of the subject computer. The boot-from-appliance process also results in a re-booting of the subject machine.

[0037] On reboot, the operation begins **503** again and follows the same execution path as previously, except that at the determination **507** of the presence of an operating system, the operation finds the installed operating system. Execution proceeds from that point as if an

10 operating system had been found originally during the first iteration.

[0038] After an operating system is located **507**, the user identifies **508** himself or herself through the authentication methods inherent in the operating system. On login, the operating system detects **509** the presence of the appliance. The result of detecting the appliance **509** is as previously described with reference to the backup procedure, namely that the operating system

15 executes the AUTORUN.INF file or similar automatically-executing file from the media.

[0039] The user may be given the option in one embodiment (shown) to elect **510** to perform restoration immediately or not. If the user elects to not perform a restoration immediately, then the user may be given access to a host of optional basic functions **531**. These optional basic

20 functions **531** use the installed operating system to provide the user with temporary access to network services, such as e-mail, instant messaging and web browsing, as well as local and remote file access and transfer, and the like. As access may be provided to local files, the basic

functions may also be used to re-establish Virtual Private Networking (VPN) connections and other encrypted communications. The optional basic functions **531** may be useful to provide the user access to on-line support services prior to initiating a restore procedure that may

25 permanently delete or modify files. The optional basic functions **531** may also provide a

platform through which a user may work to meet or change critical deadlines that might come due while the computer system is otherwise inoperable. The optional basic functions **531** may provide for a directory exploratory system, of the type common to many operating systems, in order to facilitate file operations within the installed operating system. In one embodiment, the 5 directory exploratory system is configurable to mimic the interface provided by the directory exploratory system provided by the user's normal operating system.

[0040] Similarly, the optional basic functions **531** may provide a listing of the recently used files and favorite web sites, derived from information residing on the local file system (as these same functions are provided frequently in the normal operating system). As with the directory 10 exploratory system, these lists may be provided to the user via an interface that mimics the user's normal operating system, so as to eliminate the need to learn a new system in order use the computer from the installed operating system. The user may elect to exit the optional basic functions **531**, in which case execution returns to the election **510** of the restoration of the operating system.

15 [0041] In an alternative embodiment, the optional basic functions **531** may be omitted, to provide a simpler restoration program with fewer options to the user. In this case, the election **510** of the restoration of the operating system is moot, and execution would proceed with the next query.

20 [0042] The next query made by the system is whether **511** the system is configured for automatic restoration. As with the backup procedure, the selection of automatic configuration may be a previously-made selection which is memorialized in data configuration files on the appliance. However, there may be instances when, for example if only a partial restoration is desired, full automatic restoration is not desirable. Accordingly, automatic restoration may be disabled, in which case the user must manually initiate **513** the restoration procedure. Such

initiation **513** may occur in any of the several ways well-appreciated in the art, such as a command line directive or the clicking of an icon.

[0043] In either eventuality, execution proceeds to check **515** the authorization for restoration at the computer level. The authority of the user may be derived from the current operating system login or may be separately entered by the user. Alternatively, it may not exist at all, for example in the instance that a new instantiation of the operating system is created on the computer with only a generic login. Unlike prior authorization checks that ensured proper access to the hardware (such as the BIOS authentication check **504**) and ensured proper access to the operating system and/or network (such as the operating system authentication check **508**), the restoration authorization check **515** ensures that a user has the authority to overwrite the information on his or her hard drive. This authorization helps ensure, particularly in large organizations, that users do not unintentionally or maliciously destroy the contents of their hard drives.

[0044] The authorization is evaluated **523** to ensure it is of sufficient level to permit restoration. It will be appreciated that, if a full operating system restore is desired, supervisor-level access will be needed in order to ensure that the operating system files may be overwritten. If access is not of a sufficient level, the user may be prompted **525** to enter additional or new credentials, which are in turn re-evaluated **515** and checked **523** to ensure that they meet the minimum levels required. Optionally, the user may be provided the option to terminate **529** the operation rather than to enter valid authorization credentials.

[0045] Once authorization is ensured, the system copies **527** the files from the data storage appliance to the hard drive of the computer. It is anticipated that files will be copied on a file-by-file basis, rather than bit-by-bit, as was the case with the backup procedure. The file-by-file restoration process optionally permits a user to select the files are to be restored, allowing the partial restoration of only certain lost or corrupted files, rather than the entire system. It will

further be appreciated that the file-by-file basis allows restoration to be accomplished to a new hard drive, regardless of its similarity to the geometry of the old hard drive. If the backup/restore system disclosed is used in a multiple-computer environment, the system may allow the selection of the backup from one computer onto another computer.

5 [0046] It will be appreciated that this file copying process may occur in several different manners and may use a great number of features already well known in the art. For example, the file restoration process may intelligently track incremental backups and prompt the user for a switch of media in order to ensure the most recent backup is restored. By way of further example, the restoration procedure may restore compressed backup files by uncompressing those
10 files to the hard drive. Each of these and many other backup/restore features well known in the art may be applied to the instant invented system.

[0047] The process ends 529 with the post condition of either a partially or fully-restored hard drive on the computer or an error condition (such as failure of authentication).

15 [0048] Detail of the process to boot 521 an operating system from the program appliance is shown with reference to **Fig. 9**. **Fig. 9** depicts the process 901 for booting from the program appliance and begins 903 with the precondition of a non-existent or non-properly functioning operating system on a computer, with the program appliance of the instant invention attached to that computer.

20 [0049] The appliance of the instant invention may be equipped with a Preboot eXecution Environment (PXE) image server. The computer accesses 905 the PXE image server in the same manner in which the computer might access such a server running in a network environment. The PXE server accesses 907 a PXE image stored on the program appliance. The PXE image contains the recover operating system files and specifies their location, in the manner that is already well-appreciated in the art.

[0050] The program appliance then causes the computer to install **909** the recovery operating system onto the hard drive of the subject computer. The computer then executes a self-reboot **911**. The procedure ends **913** with the post condition of the computer rebooting, which will in turn cause the computer to boot to the newly-installed recovery operating system from the hard

5 drive.

[0051] Accordingly, the instant restoration system provides a system which is simple enough to be used by any user and may, in certain embodiments, be programmed to operate completely without user intervention, requiring the user to merely plug the appliance into the computer. The same system, however, can operate with sufficient flexibility and power to permit it to be used

10 within several layers of security to perform complex partial-restoration operations. Even in these cases, however, the described system provides greater simplicity and less room for user error.

[0052] The data structure used by the data storage device and its creation is described with reference to **Fig. 6**, which depicts the data creation process **601** for the data to be stored on the data storage appliance **613**. It is well-appreciated in the art that individual files may be read **615** from the hard drive of the subject computer and written to the data storage appliance **613** in order to accomplish a backup copy of the contents of the hard drive.

[0053] The instant invention, however, is suitable for use in multiple-computer environments and may be used to conduct multiple backups of any single or multiple computers. Accordingly, it is necessary to designate the files written to the data storage **613** so that those files may be

20 identified as to the machine and time that they are created.

[0054] Accordingly, the data creation process **601** under the instant invention affords for the query of several parameters for storage on the data storage appliance **613**. These parameters may be queried in some cases from the operating system, in other cases from a network data source, and in other cases directly from the user. Optimally, however, queries will be made directly

from the operating system or the hardware in order to minimize user error and maximize user convenience. The invention may query a machine state tag **603**, which identifies the state of the current machine. This machine state tag **603** may include a date and/or time stamp. The invention may also query the machine type **605**. The machine type **605** may identify the

5 operating system and version. Other tags may include the model number **607** and the serial number **609** of the computer which is the subject of the backup procedure. It should be appreciated that other parameters, including user-defined parameters, may also be used, such as user name, employee identification number, company department and the like in order to provide information which might be of use later during restoration.

10 **[0055]** Each of the parameters collected is passed to a storage address generator **611** routine. The storage address generator **611** combines the parameter tags in order to form a storage address, from which all of the parameter tags may be derived during the restoration process. The storage address is stored on the data storage appliance **613** with the files read **615** from the backup computer. The files read **615** are associated with the storage address in the data storage
15 appliance **613**. This association may be physical, so that the storage address is physically located adjacent to the copies of the files from the computer. However, in another embodiment, the association is only a logical one, where the files associated with a particular storage address are identified by file name.

[0056] The above-described system is well-suited for implementation in a networked or
20 distributed environment, as demonstrated in **Fig. 7** with the extended network **701** depicted. Though the extended network **701** illustrates several types of connections for the purposes of example, those skilled in the art will appreciate those connections are shown merely for example of the flexibility of the instant disclosed system and some of its possible applications. Additional modifications and permutations may be used, all conforming to the instant invention.

[0057] The instant invention may be used with several node computers 703 that are in data communication with a common network 709. Some node computers 703 may be connected to the common network 709 directly, via ports 707 directly on the network. The node computers 703 may employ various appliances of the types previously discussed. Notably, however, not all 5 node computers 703 will require the same type of appliance. Some node computers 703 may use USB appliances 711 as the program appliance; others may use CD ROM drives 723 or firmware cards 725 to provide the program of the instant invention to the nodes in a non-invasive fashion. Though the non-invasive version of the instant invention affords certain benefits, it may be desirable in some circumstances to install the program disclosed directly on the hard drive (not 10 shown) of a node computer 703 or on a second hard drive (not shown) within a node computer 703.

[0058] The distributed network 701 may employ a particular computer designated as a server 715. The server may be connected to the data storage appliance 717, which may be the disconnectable-type of appliance previously disclosed or may be a separate hard drive or bank of 15 hard drives suitable for storing the backup data. The server 715 may be directly connected to the network 709 via a port 705 or by any other number of means, well-appreciated within the art.

[0059] In the distributed network 701, some of the node computers 703 may be located 20 remotely from the network 709. In some cases, a router 719 may provide interface between the network 709 and another network system on which the node computer operates. In other cases, modems 721, satellite links or other telecommunication connections may be utilized to provide remote access from the computer node 703 to the network 709.

[0060] The instant invention provides the flexibility for use in such a distributed network system 701. It will be appreciated that the system described previously with respect to Figs. 3, 4, and 5 will operate transparently of the distributed network system 701, even of the diversity of

the one described herein. Accordingly, the instant invention provides great flexibility for use in large or small computer systems and networks.

[0061] The instant invention provides a means for optimization of the data storage appliance in a manner shown with reference to **Fig. 8**. **Fig. 8** discloses an example 801 of the data storage 5 appliance 815 optimized for use in backups of a set of computers 803, 805, 807 according to the instant invention.

[0062] Shown is a first computer 803 having a first hard drive 809 having on it a file M 817, a file N 819 and a file X 821. Though the files 817, 819, 821 are identified singularly, it will be appreciated that any one of them could be substituted with a set of files without affecting the 10 operation of the instant system. Similarly, though three files are shown with simplified file names, more than three files (and likely many more than three files) with much more complex file names may be used under the instant system.

[0063] When the first computer 803 is backed up under the instant invention, the program appliance (not shown) attached to the first computer 803 causes file M 817 from the first hard 15 drive 809 to be copied to the data storage appliance 815, where it is stored as file M 839. Similarly file N 819 is copied to file N 841 and file X 821 is copied to file X 845. The storage file address is computed in the manner previously described, associated with file M 839, file N 841, and file X 845, and stored in a storage address file 851 on the data storage appliance 815.

[0064] As was previously referenced, a second computer 805 having a second hard drive 811 20 may also be backed up onto the same data storage appliance 815 under the instant invention. For the purposes of this example, the second hard drive 811 has on it file M 823, file O 825, and file Y 827. It will be appreciated that file M 823 contains the same data as the previously-backed up file M 817. This situation occurs frequently, particularly in the computer systems of large organizations, where identical application and operating system files may be on several

computers. The instant invention includes a means to determine whether a particular file to be backed up is already on the data storage appliance **815**.

[0065] Detection of unity of files may be accomplished via several different methods. A bit-by-bit comparison may be made of files, but such a comparison would require the reading and 5 transmission of the entire file. Portions of the subject file may be subject to bit-by-bit comparison. Unity of files may also be detected by the storage of a checksum in the storage address file **851** and the computation of a similar checksum on the second computer **805**. Similarly, the size and date stamp of files may be compared. Combinations of each of these methods may also be used in order to determine which files already exist on the data storage 10 appliance **851**.

[0066] This example assumes that the files on the data storage appliance **815** are associated with their respective machines on the logical basis previously described, rather than using physical proximity to determine the association. Once it has been determined that file M **823** already exists on the data storage appliance **815**, file M **823** need not be recopied. Rather, 15 annotation is made in the storage address file **851** to associate file M **839** with both the first computer **803** and the second computer **805**.

[0067] If it is determined that certain files, such as file O **825** and file Y **827** are not present on the data storage medium **815**, those files are copied to corresponding files **843**, **847** on the data storage medium **815**. Updates are made to the storage address file **851** to associate file O 20 **843** and file Y **847** with the second computer **805**.

[0068] A third computer **807** having a third hard drive **813** may contain several files **831**, **833**, **835**, **837** at a certain point in time. Those files may be backed up to the data storage appliance **815** in the manner described, so that ultimately the storage address file **851** associates file M **839**, file N **841**, file Z **849** and file O **843** with the third computer **807**. As time passes,

changes may be made to a file, such as file Z **835**, on the third computer **807**. While an appendage **853** is shown to file Z **835**, it will be appreciated by those skilled in the art that any number of additions, deletions or modifications could be made to file Z **835** over time.

[0069] When a second backup is made of the third computer **807** under the instant invention,
5 the instant invention detects the presence and unity of file M **839**, file N **833** and file O **837** on the data storage appliance **815**. Those files are not recopied, but associated with the second backup time stamp within the storage address file **851**. The new file Z **835** and **853**, however, is not present on the data storage appliance **815** and is copied to a second file Z **855**, being associated with the third computer **807** and the second time in the storage address file **851**.

10 [0070] In this way, not only is the time of the backup operation reduced by not requiring transmission of a copy of the file to the data storage appliance **815**, but the storage space within the data storage appliance **815** is used more efficiently, permitting more computers to use a single data storage appliance **815**.

[0071] As to the manner of operation and use of the present invention, the same is made
15 apparent from the foregoing discussion. With respect to the above description, it is to be realized that although embodiments of specific material, representations, databases, and languages are disclosed, those enabling embodiments are illustrative and the optimum relationships for the parts of the invention are to include variations in composition, form, protocol, function, and manner of operation, which are deemed readily apparent to one skilled in the art in view of this
20 disclosure. All relevant relationships to those illustrated in the drawings and this specification are intended to be encompassed by the present invention.

[0072] Therefore, the foregoing is considered as illustrative of the principles of the invention and since numerous modifications will readily occur to those skilled in the art, it is not desired to

limit the invention to the exact construction and operation shown or described. All suitable modifications and equivalents may be resorted to, falling within the scope of the invention.